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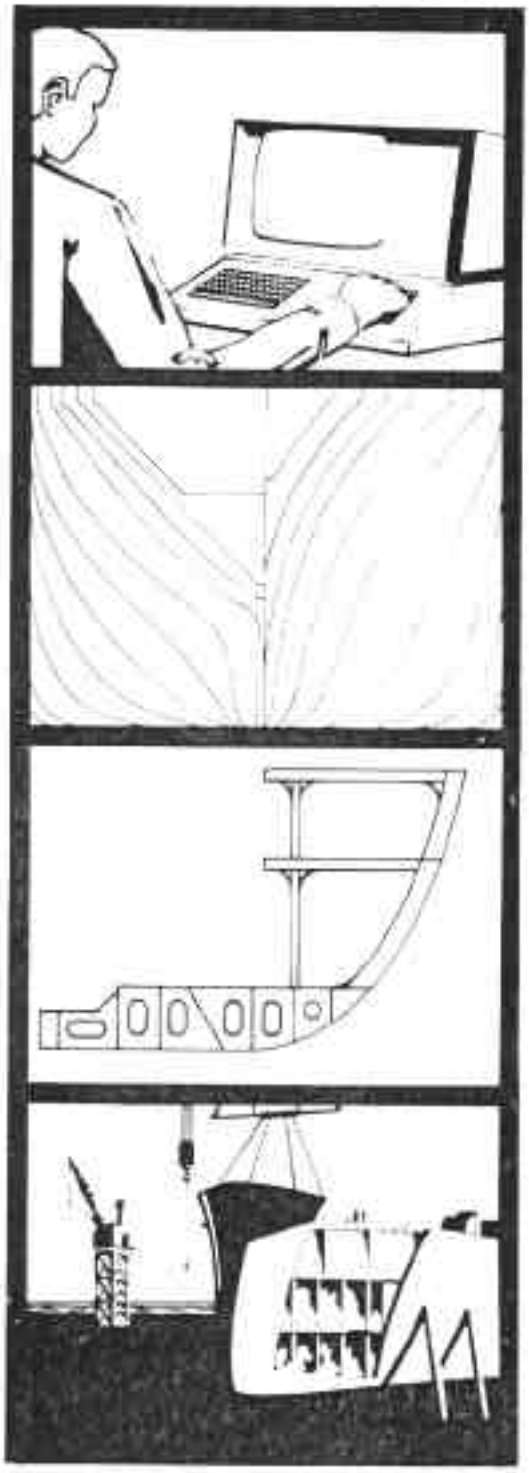

R ESEARCH
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FOR
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AND
P RODUCTIVITY
IN
S HIPBUILDING

Proceedings of the
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September 11-13, 1979
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AN INTEGRATED INTERACTIVE PLATE NESTING AND MANUFACTURING PLANNING SYSTEM

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For the past 25 years, Mr. Wallent has been involved in the production areas of shipbuilding and in computer applications. He has held the position of Manager at a software vendor company, and has assisted many yards in the United States and Canada over the years.

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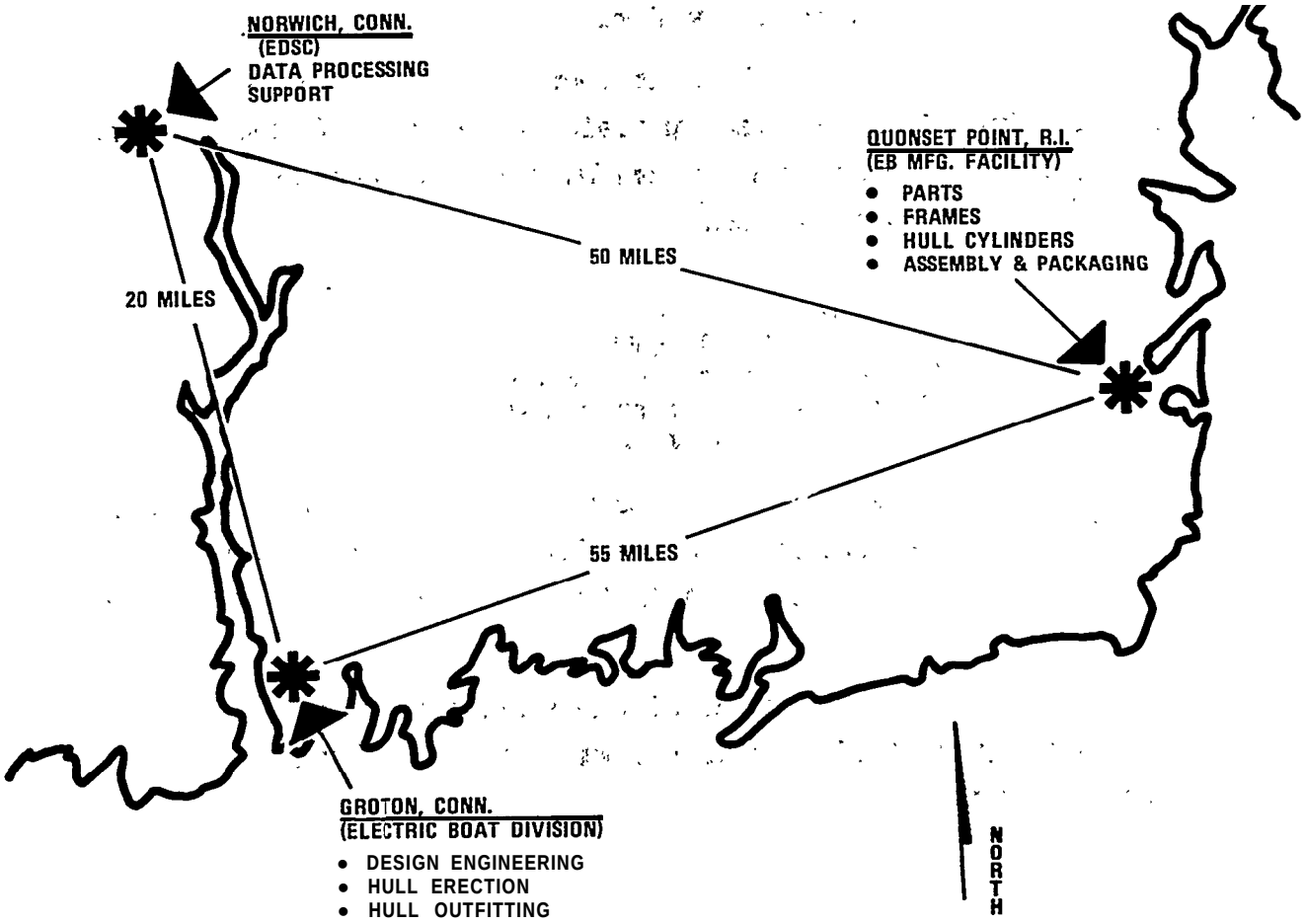
Mr. Cofoni previously held the position of systems analyst, responsible for data processing support of structural computer aided design and manufacturing at General Dynamics.

FOR THOSE OF YOU WHO ARE NOT FAMILIAR WITH THE FUNCTIONAL RELATIONSHIPS BETWEEN ELECTRIC BOAT GROTON AND THE QUONSET POINT MANUFACTURING FACILITY, THEY ARE SEPARATED BY APPROXIMATELY 55 MILES. THE QUONSET FACILITY PERFORMS PART, FRAME AND HULL CYLINDER FABRICATION, AND ASSEMBLY AND PACKAGING OPERATIONS. SHEET METAL, ELECTRICAL, PIPE AND MACHINE SHOPS ARE ALSO LOCATED AT QUONSET. MAJOR ITEMS ARE BARGED TO GROTON WHERE DESIGN ENGINEERING FUNCTIONS, HULL ERECTION OUTFITTING, AND OVERHAUL ARE PERFORMED.



TYPE OF WORK

LARGE CONSTRUCTION UNITS

- LONG LEAD AND STAGING TIME
- LOW RESPONSE TO SCHEDULE CHANGES

SMALL CONSTRUCTION UNITS

- PARTIAL PLATE NESTING
- LOW STEEL UTILIZATION
- EXCESSIVE MATERIAL HANDLING
- LOW MACHINE UTILIZATION

ABOUT TWO YEARS AGO OUR FACILITY UNDERWENT SOME MAJOR CHANGES IN MANAGEMENT AND IN PHILOSOPHY. A HARD LOOK WAS TAKEN AT OUR METHODS OF OPERATION AND WHAT STEPS NEEDED TO BE TAKEN TO MAKE US MORE PROFITABLE. THE SIZE OF WORK UNITS HAVE TREMENDOUS VARIATIONS IN TIME SPANS, FROM A FEW DAYS TO TWO YEARS, AND SPECIAL PROBLEMS WERE IDENTIFIED WITH BOTH LARGE AND SMALL UNITS.

OUR PLANNING AND SCHEDULING SYSTEMS WERE DONE BY HAND AND THE WORK WAS REPEATED FOR EACH SUCCESSIVE HULL. ALL WORK WAS SCHEDULED TOE TO HEEL AND EACH UNIT TREATED AS AN ENTITY OF ITSELF. THIS METHOD CAUSED US TO CUT AND FORM THE ENTIRE UNIT BEFORE THE START OF ASSEMBLY. FOR LARGE UNITS LONG LEAD TIMES WERE REQUIRED WHICH CAUSED SLOW RESPONSE TO SCHEDULING, AND IN ADDITION LARGE PARTS INVENTORIES WERE BEING MAINTAINED. MANY PROBLEMS WERE ENCOUNTERED WITH CHANGES DURING THE STORAGE PERIOD.

FOR SMALL UNITS PLATE UTILIZATION BECAME A PROBLEM. PARTIAL PLATE NESTING WAS BEING DONE TO MAINTAIN UNIT INTEGRITY. THIS CAUSED EXCESSIVE MATERIAL HANDLING AND LOW CUTTING MACHINE UTILIZATION.

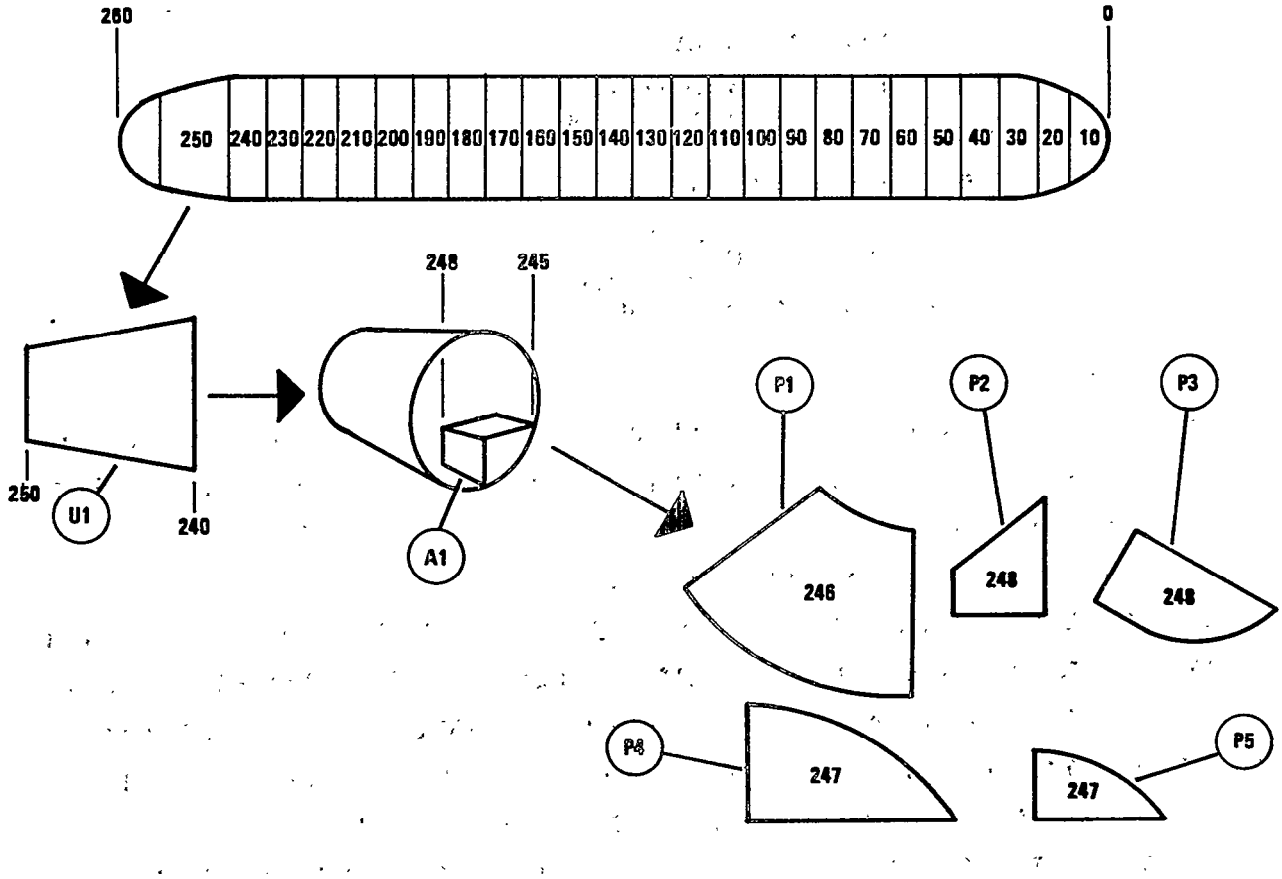
REQUIREMENTS

- REDUCE STAGING INVENTORY
- PROVIDE PLANNING AND SCHEDULING PAPER AUTOMATICALLY
- IMPROVE PLATE AND EQUIPMENT UTILIZATION

IT WAS DECIDED TO PUT A SYSTEM TOGETHER TO MEET THREE SPECIFIC REQUIREMENTS.

1. REDUCE THE STAGING INVENTORY TO SOME SPECIFIED WORKING TIME SPAN.
2. PROVIDE A METHOD TO PLAN AND PRODUCE SCHEDULING AND TRADE WORK INSTRUCTIONS AUTOMATICALLY.
3. IMPROVE THE PLATE AND EQUIPMENT UTILIZATION TO A MORE ACCEPTABLE LEVEL.

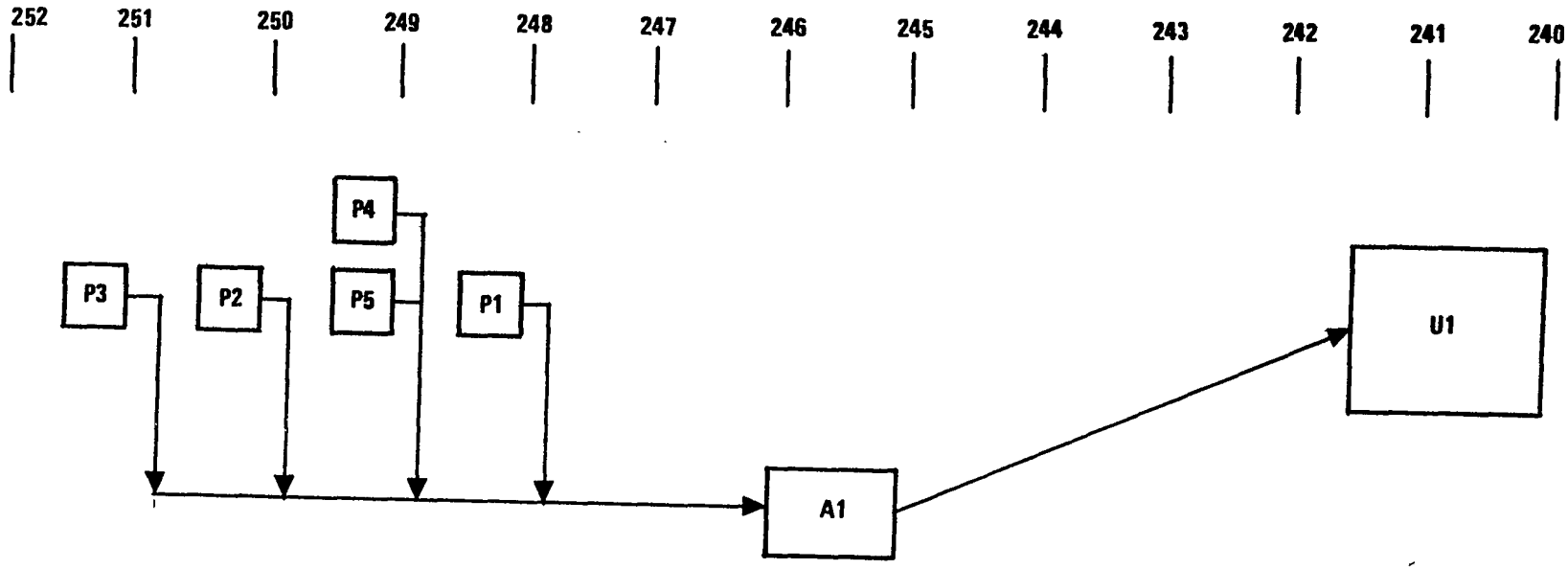
ASSEMBLY SEQUENCE



THE FIRST STEP IN ACCOMPLISHING THESE GOALS HAS TO ESTABLISH A METHOD OF WORKING WITH THE MATERIAL REQUIRED DURING A TIME FRAME RATHER THAN BY TOTAL UNITS. TO DO THIS, EACH SHIP (SUBMARINE IN OUR CASE) WAS DIVIDED INTO UNITS REPRESENTING THE NUMBER OF WEEKS OF CONSTRUCTION. ZERO WAS DESIGNATED AS REPRESENTING DELIVERY OF THE HULL. THE DELIVERY DATE OF EACH UNIT FOR ASSEMBLY TO THE MAIN HULL WAS THEN FIXED AT ITS CORRESPONDING WEEK. SUB-UNITS AND PARTS WERE BROKEN OUT AND ALSO ASSIGNED WEEK NUMBERS.

THIS CHART IS A GRAPHIC REPRESENTATION OF HOW THIS IS ACCOMPLISHED. THE COMPLETION DATE (TIED TO THE SEQUENCE) IS ESTABLISHED FIRST AND SPAN TIMES FOR EACH PRIOR OPERATION BACKED OUT UNTIL THE CHART IS COMPLETED.

MANUFACTURING METHOD



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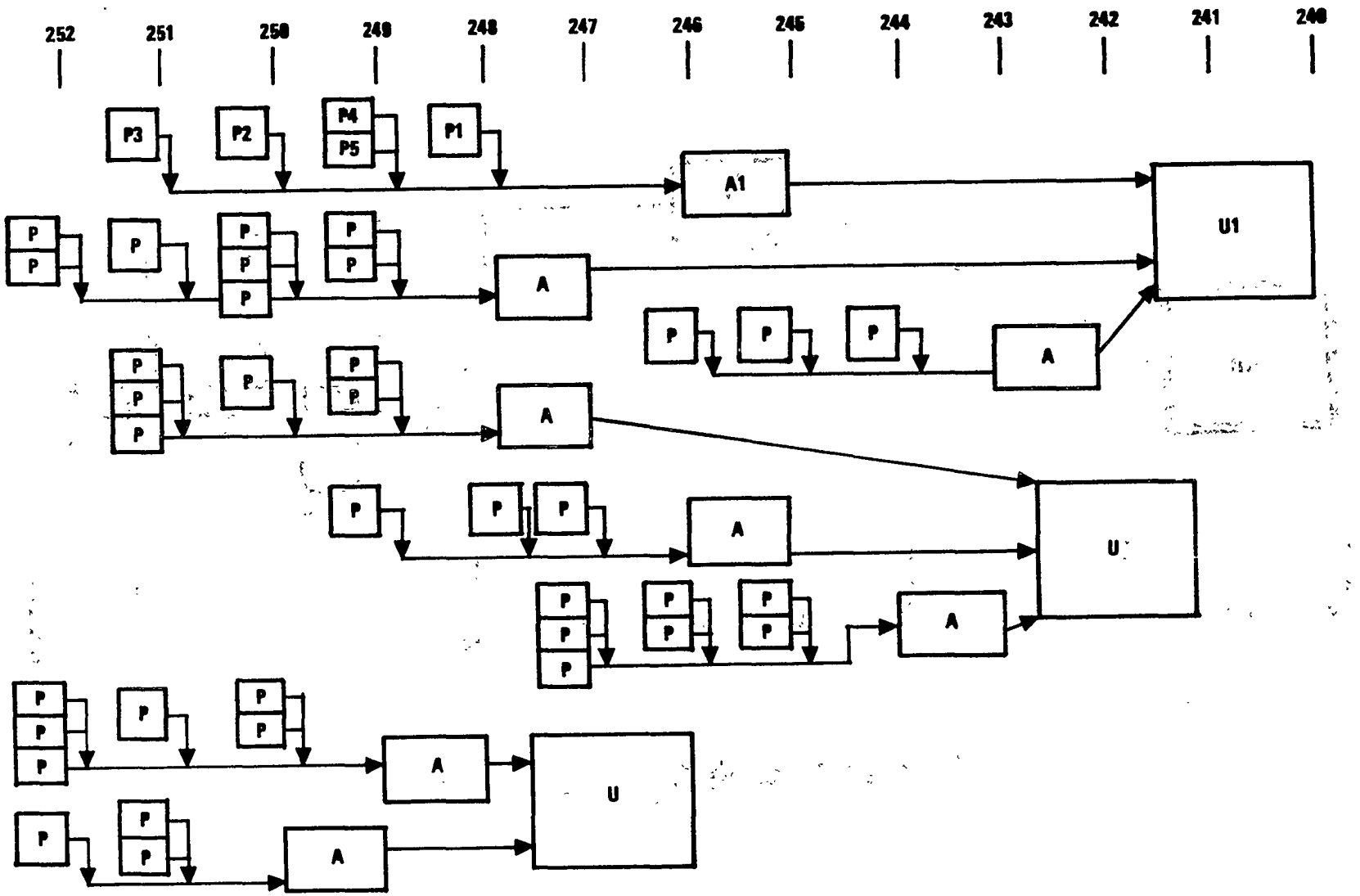
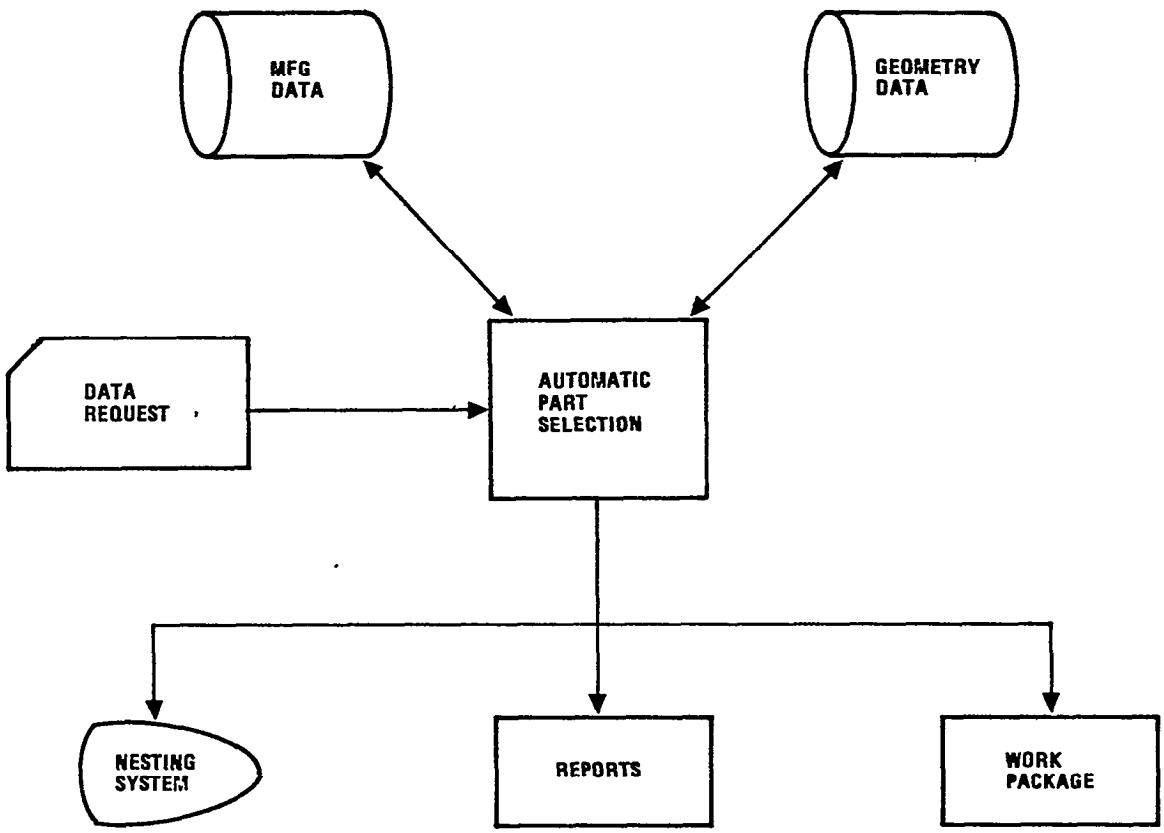
MANUFACTURING MODEL



THIS SLIDE SHOWS HOW SEVERAL UNITS LOOK WHEN OVERLAID. A "WINDOW" OF THE DESIRED TIME FRAME IS TAKEN AND THE CANIDATES FOR NESTING CAN THEN BE EASILY IDENTIFIED.

INFORMATION ABOUT EACH UNIT IS LOADED INTO A COMPUTER FILE DOWN TO THE PART LEVEL.

OVERVIEW OF STRUCTURAL CAM SYSTEM



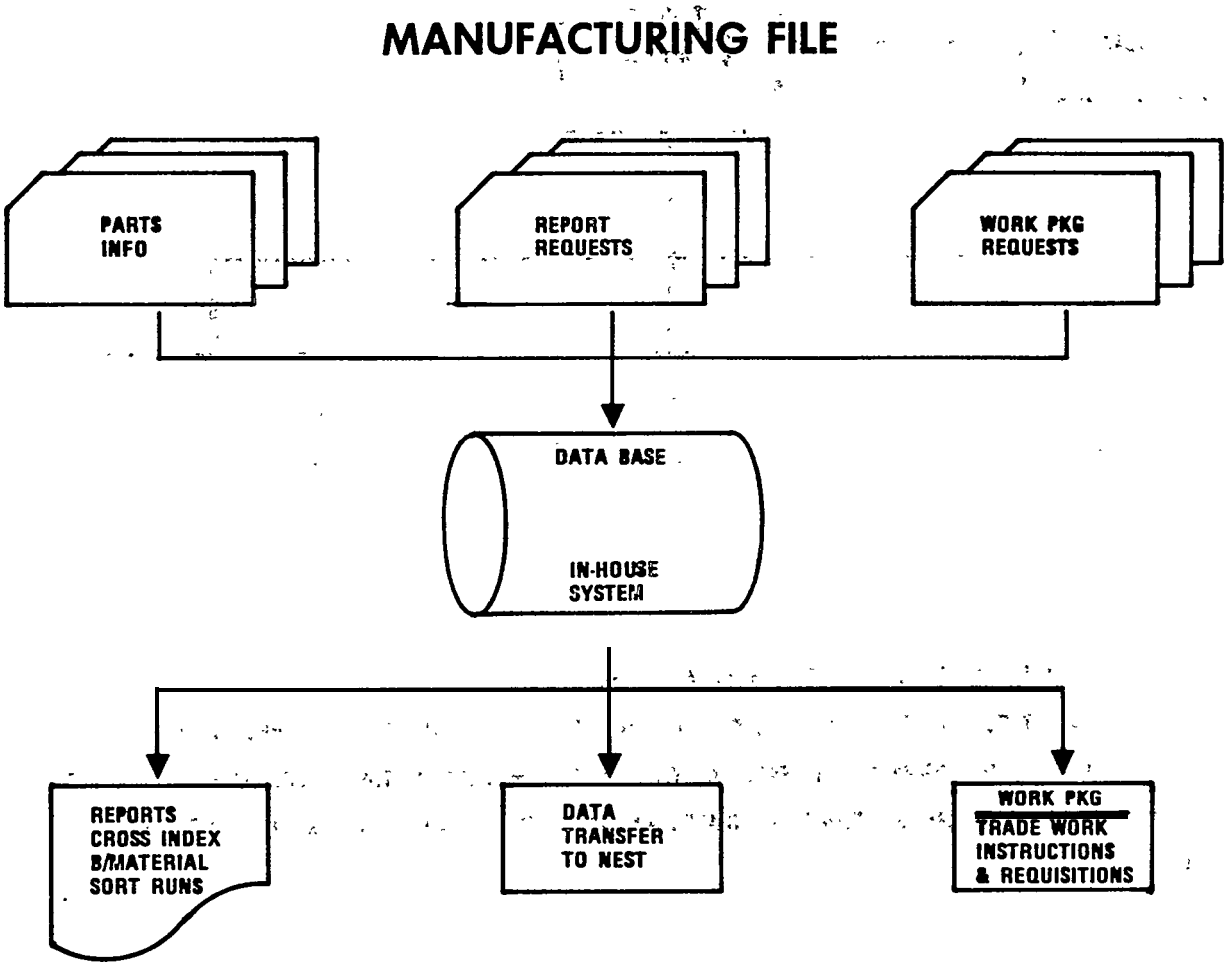
THE COMPUTERIZED SYSTEM IS COMPRISED OF THREE MAJOR MODULES.

THE MANUFACTURING DATA FILE, THE GEOMETRY FILE, AND THE INTERACTIVE NESTING SYSTEM. THESE THREE ARE TIED TOGETHER BY A SELECTION PROGRAM WHICH REACTS BY THE SEQUENCE NUMBERS OF THE REQUESTED HULLS. RULES ARE APPLIED IDENTIFYING WHICH ARE LEGITIMATE CANIDATES AND AN AUTOMATIC CHECK OFF IS MADE TO TRACK COMPLETED OPERATIONS.

MANUFACTURING PLANNING

- FABRICATION AND ASSEMBLY SEQUENCES
- SPAN TIMES AND LEAD TIMES
- FEED TO FEED RELATIONSHIPS
- COMPLETION PERIOD
- MATERIAL REQUIREMENTS

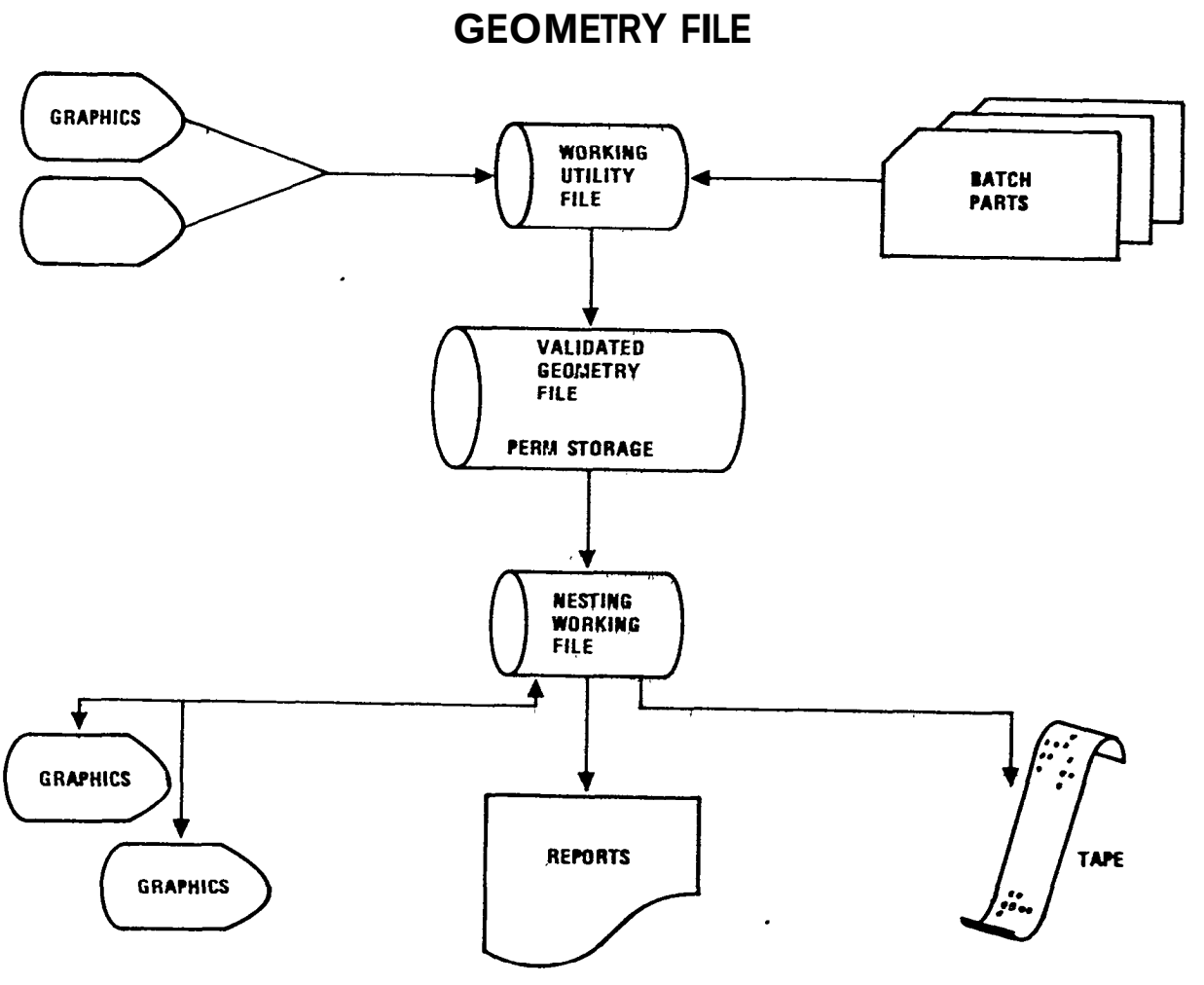
THE MANUFACTURING FILE HAS A 300 CHARACTER RECORD FOR EACH PART. THIS INFORMATION STARTS WITH IDENTIFICATION OF THE RAW STOCK AND ENDS WITH THE COMPLETED UNIT. THE SEQUENCE NUMBERS FOR EACH STEP ARE ASSIGNED, THE GEOMETRY IDN (AUTOKON NO.), ALL SPAN TIMES FOR CONSTRUCTION, LEAD TIMES FOR FLOOR PLANNING, FEED TO FEED RELATIONSHIPS, CHARGE NUMBERS, AND COMPLETION DATES ARE LOADED IN THIS FILE.



AUTOMATED OUTPUTS

- MATERIAL REQUISITIONS
- TRADE WORK INSTRUCTIONS
- BILL OF MATERIAL/STAGING AND ASSY INVENTORY LISTS
- PLANNING REPORTS

AUTOMATED OUTPUT FROM THE MANUFACTURING FILE CONSISTS OF MATERIAL REQUISITIONS FOR EACH FIRST USER, TRADE WORK INSTRUCTIONS AT THE WORKING LEVEL, BILL OF MATERIALS AND STAGING LISTS, AND REPORTS FOR PLANNING AND STATUSING.



THE GEOMETRY FILE IS LOADED IN SEVERAL WAYS DEPENDING ON THE COMPLEXITY OF THE PART. THE LARGEST INPUT IS PRESENTLY BY BATCH AND IS PROCESSED THROUGH THE AUTOKON LANGUAGE. IN ADDITION, GRAPHICS TERMINALS ARE USED TO INITIATE NEW WORK OR FOR MAKING CHANGES TO EXISTING PARTS. AS PARTS ARE VALIDATED, THEY ARE TRANSFERRED FROM THE WORKING FILE INTO PERMANENT STORAGE.

WHEN NESTING IS TO BE DONE, A REQUEST IS MADE THROUGH THE SELECTION MODULE. THE DATA FROM THE MANUFACTURING FILE IS ANALYZED, ELIGIBLE PARTS ARE SELECTED, AND A TRANSFER IS INITIATED TO THE NESTING SYSTEM.

THIS SYSTEM HAS ITS OWN WORKING FILE AND USES TWO GRAPHICS TERMINALS. IT OUTPUTS REPORTS AND TAPES TO DRIVE NUMERICALLY CONTROLED FLAME CUTTERS.

THE BALANCE OF THIS PRESENTATION IS BEING GIVEN BY MR. PAUL COFONI. HE WILL DISCUSS THE INTERACTIVE NESTING SYSTEM IN MORE DETAIL AND ALSO WILL TALK ABOUT PLANNED FUTURE ENHANCEMENTS FOR OUR STRUCTURAL CAD/CAM.

IN PARTING, LET ME MENTION THAT SOME SPECIAL CONSIDERATIONS WERE GIVEN TO THE TYPE OF PERSON BEST SUITED TO TAKE FULL ADVANTAGE OF OUR HIGHLY INTERACTIVE NESTING SYSTEM. AFTER SOME DILIGENT RESEARCH AND EXAMINATION OF SPECIFICATIONS, OUR INDUSTRIAL RELATIONS DEPARTMENT CAME UP WITH THIS ARTISTS CONCEPTION OF THE PERFECT CANIDATE . . . .

BY MAINTAINING WITHIN THE MANUFACTURING PLANNING FILES REFERENCES TO THE AUTOKON GEOMETRY FILES, PARTS REQUIRED FOR NESTING WITHIN A GIVEN PERIOD ARE AUTOMATICALLY RETRIEVED AND TRANSFERRED VIA TELECOMMUNICATIONS FROM NORWICH, CONNECTICUT TO QUONSET POINT, RHODE ISLAND, WHERE THEY ARE STORED IN THE NESTING SYSTEM'S WORKING FILES. SIMULTANEOUS TO TRANSFER, THE SELECTED PARTS ARE SORTED BY MATERIAL TYPE AND THICKNESS AND A PICTORIAL BOOKLET IS PREPARED FROM A NEUTRAL GRAPHICS FILE ON DRUM OR FLATBED PLOTTER OR ON STORAGE TUBE DEVICES. INFORMATION SUCH AS PART IDENTIFICATION, ENGINEERING DRAWING NUMBER AND THE PARTS LOCATION AND QUANTITY ARE DISPLAYED BENEATH EACH PART. THIS BOOKLET IS USED BY THE NESTER FOR PLANNIHG OF HIS INTERACTIVE SESSION.

NESTING ITSELF BEGINS WITH THE NESTER TAKING ADVANTAGE STATE-OF-THE-ART INTERACTIVE GRAPHICS. THE HARDWARE SELECTED IS MANUFACTURED BY ADAGE CORPORATION AND CONSISTS OF A MINICOMPUTER USED PRIMARILY FOR DATA MANAGEMENT AND TELECOMMUNICATIONS, A DISK DRIVE FOR DATA STORAGE, AN ELECTROSTATIC PRINTER-PLOTTER FOR QUICK PLOTTING CAPABILITIES, AND A MICROPROCESSOR USED TO CONTROL TWO GRAPHICS WORKSTATION. EACH WORKSTATION CONSISTS OF A REFRESH VECTOR DISPLAY SCREEN WITH 8K BY 8K RESOLUTION, ALPHANUMERIC KEYBOARD, DIGITIZING TABLET AND STYLUS, 32 FUNCTION SWITCHES, 6 VARIABLE CONTROL DIALS AND TWO FOOT PEDALS. THE APPLICATION SOFTWARE WAS DEVELOPED BY AH ITALIAN SHIPYARD. ITALCANTIERI AND REPRESENTS OVER 12 MAN-YEARS OF EFFORT BY THAT COMPANY.

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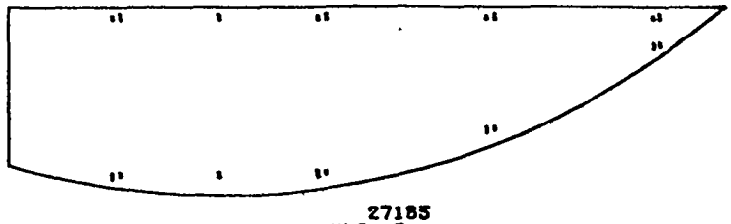

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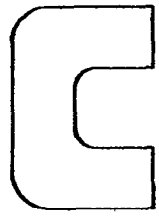

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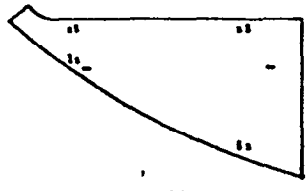

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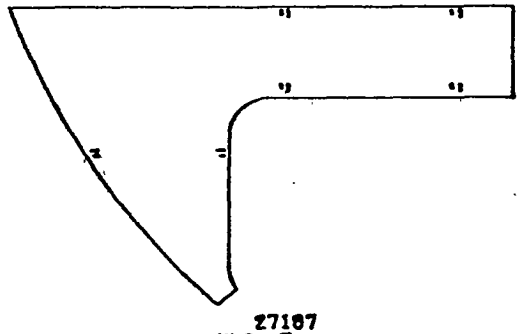

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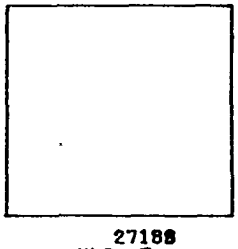

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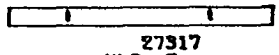

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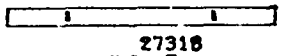

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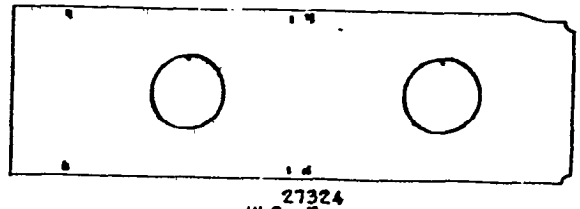

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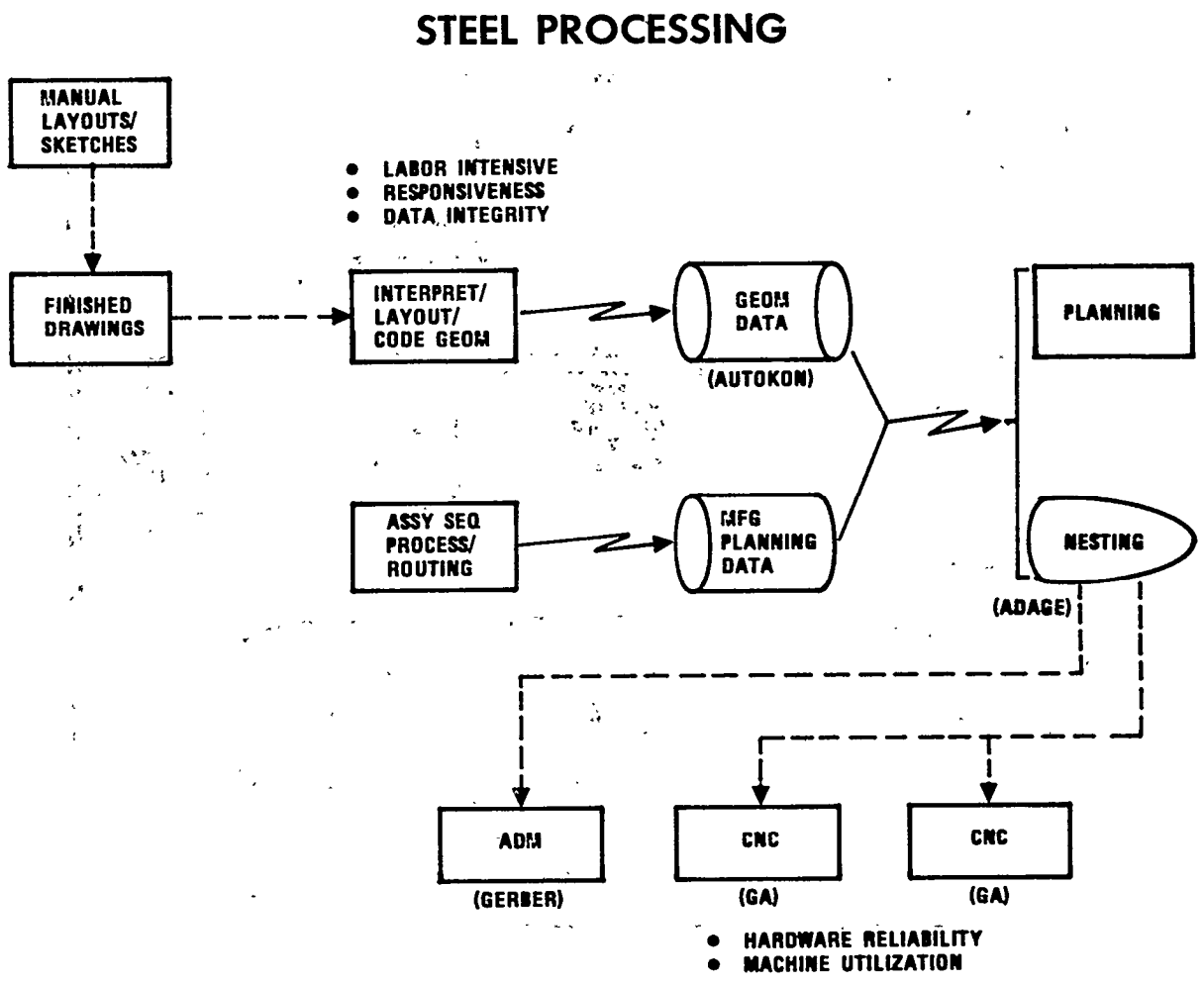
TAKING ADVANTAGE OF THE SYSTEM'S HIGH RESPONSIVENESS AND VERSATILLTY IN THE MANIPULATION OF GEOMETRY, THE NESTER POSITIONS PARTS AND DEFINES CUTTING PATHS AND EDGE PREPARATIONS. WITH THE INCREASED SPEED OF NESTING, MANY VARIATIONS OF NEST FORMATS CAN BE ATTEMPTED IN A MATTER OF MINUTES, PROVIDING AN OPPORTUNITY TO SELECT THE BEST NEST FORMAT BASED ON PLATE AND BURNING MACHING UTILIZATION.

THE SYSTEMS ABILITY TO AUTOMATICALLY MEASURE PART POSITIONAL DATA ELIMINATES ERRORS COMMONLY ASSOCIATED WITH MANUAL MEASUREMENT, DATA TRANSCRIPTION AND KEYPUNCHING. AUTOMATIC PART INTERFERENCE DETECTION REDUCES THE NEED FOR CLOSE VISUAL INSPECTION AND CONTINUOUS MDNITORING AND DISPLAY OF PLATE UTILIZATION PERCENTAGES PROVIDES MANAGEMENT INFORMATION TO AID IN CONTROLLING SCRAP RATES. THE INTERACTION BETWEEN MAN AND MACHINE CAPITALIZES ON THE JUDGEMENT, EXPERIENCE, AND TALENTS OF THE INDIVIDUAL AND THE SPEED OF THE COMPUTER. THE ABILITY TO DO EASILY, WHAT BEFORE WAS TEDIOUS, WITH IMPROVEMENT TO THE PRODUCT QUALITY SERVES AS POSITIVE MOTIVATION FOR THE NESTER AND FOSTERS EXCELLENCE IN INDIVIDUAL PERFORMANCE.



TODAY AT THE ELECTRIC BOAT DIVISION OF GENERAL DYNAMICS, STRUCTURAL DESIGN LAYOUTS, SKETCHES AND FINISHED CONTRACT DRAWINGS ARE PRODUCED USING TRADITIONAL MANUAL DRAFTING TECHNIQUES. AS PARTS ARE REQUIRED BY MANUFACTURING THE GEOMETRY OF THE PARTS ARE INTERPRETED FROM THE FINISHED DRAWINGS AND LOADED INTO GEOMETRY FILES IN SUPPORT OF NESTING FOR AUTOMATED BURNING OPERATIONS. THE MEDIA USED FOR AUTOMATED BURNING DATA IS PAPER TAPE.

A PROJECT WHICH WILL BE IMPLEMENTED AND IN PRODUCTION BY THE END OF THIS YEAR IS THE INTEGRATION OF AND INTER-ACTIVE GRAPHICS SYSTEM FOR STRUCTURAL DESIGN/DRAFTING. THE SYSTEM WILL SUPPORT 10 PRODUCTION WORKSTATIONS FOR DESIGN/DRAFTING OPERATIONS. IT WILL PRODUCE AS ITS PRIMARY PRODUCT FINISHED CONTRACT DRAWINGS USING A HIGH SPEED PLOTTING DEVICE. THE SYSTEM WILL BE INTEGRATED WITH THE AUTOKON STRUCTURAL SYSTEM TO PROVIDE FOR TRANS-MITTAL OF GEOMETRY TO THE MANUFACTURING DATA BASE, AS THE GEOMETRY IS DEFINED DURING THE DESIGN PHASE. THE SYSTEM WILL INCREASE PRODUCTIVITY DURING BOTH SUBMARINE DESIGN AND MANUFACTURING, AND WILL SHORTEN LEAD TIMES BETWEEN PRELIMINARY DESIGN AND DETAILED DESIGN AND MANUFACTURING.
THIS WILL BE ACCOMPLISHED BY; REPLACING MANUAL DRAFTING WITH AUTOMATED DRAFTING; BY CAPTURING STRUCTURAL GEOMETRY AT THE TIME IT IS DEFINED INITIALLY IN A COMPUTER DATA BASE; AND BY PROVIDING DETAILED GEOMETRY TO MANUFACTURING PERSONNEL SAVING THEM BOTH DRAWING INTERPRETATION AND PART CODING TIME.
ANOTHER PROJECT PROPOSED FOR THE 1980 IS THE IMPLEMENTATION OF DIRECT NUMERICAL CONTROL/COMPUTERIZED NUMERICAL CONTROL SYSTEMS FOR AUTOMATED BURNING AND WELDING OPERATIONS. THE DNC/CNC SYSTEMS WOULD REPLACE PAPER TAPE WITH HIGH SPEED COMMUNICATION LINES WITH PAPER TAPE AS A BACKUP INPUT MEDIA. THE SYSTEM WILL BE FULLY INTEGRATED WITH THE ADAGE NESTING SYSTEM, SO THAT FINISHED NEST FORMATS CAN BE ROUTED DIRECTLY FROM THE NESTING OPERATIONS

TO BURNING OPERATIONS WITH MINIMAL MANUAL INTERVENTION. THIS PROJECT WILL PREVENT A SINGLE SOURCE OF FAILURE WITHIN BURNING/WELDING OPERATIONS AND WILL INCREASE THROUGHPUT ON THE AUTOMATED MACHINERY BY REDUCTION OF SET-UP TIME.
UPON COMPLETION OF THIS PROJECT THE STRUCTURAL DISCIPLINE AT THE ELECTRIC BOAT WILL BE ONE AUTOMATED AND INTEGRATED SYSTEM CAPITALIZING ON AUTOMATED INPUT AND OUTPUT OF DATA, EARLY AVAILABILITY OF THE DATA, AND REDUCED MANUAL INTERVENTION IN THE COMMUNICATION OF THE DATA.
THE WORD INTEGRATION HAS BEEN THE CORNERSTONE IN OUR STRUCTURAL CAD/CAM PLANNING. WHILE IMPLEMENTATION OF NEW TECHNOLOGIES ON THEIR OWN MERITS CAN BE JUSTIFIED, A LARGER PAYBACK IS SEEN IN INTEGRATING THESE TECHNOLOGIES INTO THE EXISTING SYSTEMS.
IN THE CASE OF DESIGN/DRAFTING, INTERACTIVE GRAPHICS INCREASES PRODUCTIVITY IN THE PREPARATION OF CONTRACT DRAWINGS, BUT BY INTEGRATING THE SYSTEM WITH MANUFACTURING GEOMETRY FILES, A BY PRODUCT OF THE DESIGN EFFORT BECOMES EARLY AVAILABILITY OF MANUFACTURING GEOMETRY AT REDUCED COST.
IN THE CASE OF STEEL PLATE NESTING, INTERACTIVE GRAPHICS INCREASES PRODUCTIVITY IN NESTING ITSELF BUT BY INTEGRATING THE SYSTEM TO THE EXISTING MANUFACTURING PLANNING FILES IT IS POSSIBLE TO ACCOMPLISH FULL PLATE NESTING, REDUCED MATERIAL HANDLING AND STORAGE AND HIGHPLATE UTILIZATION. AND SO INTEGRATION PROVIDES A CASCADING OF BENEFITS, AND THE JUSTIFICATION FOR IMPLEMENTING HIGHER TECHNOLOGIES BECOMES A SYSTEM JUSTIFICATION FOR A WAY OF DOING BUSINESS.

STEEL PROCESSING